Leslie Gudorf

Hog Creek Review

The Role of Visual Occlusion in Altitude Maintenance During Simulated Flight

For one to practice safety in response to unwanted contact, one must have a sense of self-displacement. Researchers examine this perceptual-motor skill as a cue for object depth; for instance, Flach et al. studied the depression angle and splay angle as visual cues from a 2-D texture. Wind disturbance became another factor of interest for its potential effect on altitude. About a decade later, experimenters used three-dimensional cues to test participants on their perceived altitudes. Winterbottom et al. studied how participants maintained altitude through altering texture density.

In attempts to expand upon previous research of one's perception when flying, Gray et al. focused on varying visual occlusion, "changes in the amount of visible ground surface between trees" (p. 486), with height, density, and radius to observe effects on maintenance throughout low-altitude, stimulated flight. They used Leung and Malik's computational model of visual occlusion to further address the negative correlation between occlusion and likelihood of ground-seeing. With this model, Gray et al. note how the affiliated variables may not only affect the degree of occlusion but also performance in flight. Their modifications resulted from acknowledgement on non-flat terrains. From analyzing these probabilities, they hypothesized a direct relationship between products of variables, tree density and height as well as tree density and radius, with altitude-maintenance performance; these observed variables were predicted to have greater influence on altitude-maintenance performance when studied systematically compared to the influence of just an individual affected variable. These predictions were tested via four experiments.

The first experiment studied vertical cues via height and density, since both vary during low-altitude flight training, to examine impact on altitude-maintenance in accordance with the changes of visual occlusion. Specifically, Gray et al. wanted to compare the product of density and height's performance with the individual performances of density and height to determine if joint variables would result in better performance of altitude-maintenance. Seventeen databases consisting of five tree densities correlating with five heights were constructed for the apparatus. All six subjects, trained pilots in stimulation, noted their altitude (sampled every 0.25 seconds), as they flew over the flat surfaces for eight seconds so they could try to maintain that altitude when they flew over non-flat surfaces for fifty-two seconds. However, a warning tone notified subjects if they ever exceeded a ten-meter deviance from the target altitude of thirty meters. They completed twenty-seven, one-minute trials in response to all conditions with intervals of at least seven seconds for a "break" between trials to limit motional habituation. Densities of 0.25, 1, 2, 4, and 64 trees/km^2 and heights of 0,2.5,5,10,20 m were studied; each trial used one tree height. However, each participant experienced the 64 trees/km^2 x 20 m twice to guarantee altitude-maintenance.

Because of this "given" facilitation, this condition was excluded from the repeated measures analyses of variance (ANOVA). Total error referred to the difference between observed altitude and target altitude and distinguished precision as variable root mean-squared (RMS) and accuracy as constant RMS error in altitude-maintenance. Upon review, variable RMS error and tree height appear as negatively correlated until it appears constant when encountered with at least a five-foot tree. In all cases, a 4 x 4 repeated measures ANOVA showed significance across the main effects for variable RMS error: height, density, and the product of height and density; there was no significance in the main effects of the 3 x 3 repeated measures ANOVA for constant RMS errors. Overall, approximately 13%-39% of variability results from tree height, and tree density accounts for 48%-71% of variance. However, a post-hoc, paired t-test showed significance in how the product of height and density accounted for 76%-84% more of the variable RMS than either of the two factors separately. Each combination of variables was calculated using a derivative of traveled distance to provide a "quantitative measure of the effectiveness of visual occlusion as a cue to altitude maintenance" (p. 482). The collected data, log of the inverse probability in seeing the ground as a function of log base ten of height-density product, significantly correlated with the visual occlusion model for all six subjects. Thus, altitude-maintenance performance correlated with the magnitude of visual occlusion through the inverse relationship between the probability in seeing the ground and variable RMS error.

Height and width differ in their effects on motional perception; therefore, both variables should also differ in their effects on altitude-maintenance performance. In efforts to study this expectation, Gray et al. used varied tree radii to observe potential differences in altitude-maintenance performances in comparison to varied tree height. The second experiment studied horizontal cues via width and density to examine impact on altitude-maintenance in accordance with the changes of visual occlusion.

Procedures for the second experiment reflected those of the first experiment. However, four different participants served as subjects and completed the same number of trials from "three tree densities (2, 4, 64 trees/km^2) and four tree radii (0, 0.5, 2.5, 5 m)" (p. 483). Because the radius of the tree foliage was manipulated, height (10 m) and tree trunk radius (0.5 m) served as a control for all trials in this experiment. Due to the insignificant effect from height and density on constant RMS error found in the previous experiment, Gray et al. focused on the variable RMS error results from tree radius, tree density, and the radius-density product. In all cases, a 3 x 3 repeated measures ANOVA showed significance across the main effects for variable RMS error: radius, density, and the product of radius and density. Overall, approximately 1%-6% of variability results from tree radius, whereas tree density accounts for 39%-61% of variance. However, a post-hoc, paired t-test showed significance in how the product of radius and density accounted for 62%-83% more of the variable RMS error than either of the two factors individually. The visual occlusion model served again as a comparison to the collected data of radius-tree combinations. The data yielded the same results: correlations ranging from 77%-87% between the model and mean variable RMS errors for all four subjects; all correlations were significant. The collected data, log of the inverse probability in seeing the ground as a function of log base ten of radius-density product, significantly correlated with the visual occlusion model for all four subjects. Thus, altitude-maintenance performance correlated with the magnitude of visual occlusion through the inverse relationship between the probability in seeing the ground and variable RMS error.

To ensure that altitude-maintenance performance was affected by the proportional dimensions of the cues and not total area, Gray et al. conducted a third experiment. In this experiment, they used the same procedures as the first two experiments with the participants from the first experiment. The trees from experiment two were replaced with trees that varied in height but remained constant in sizes of foliage, density, treetop radius, and trunk radius. Each subject participated in all twenty-seven trials. After correction for mistakenly rejecting a null hypothesis, the t-tests from this experiment resulted in no significance in mean variable RMS error and SEMs. Because tree area was removed as a cue and did not alter performance, the altitude-maintenance performance was argued to result from the changes in tree height.

Gray et al. conducted a fourth experiment which entailed the same procedures and participants as the first and third experiments. However, the trials consisted of randomly distributed, intermixed tree heights of 2.5, 10, and 20 m along the flight path; all trees had densities of 64 trees/km^2. This experiment produced no significant results in comparison to the first experiment. Thus, whether the heights remained constant or varied in each trial, the results were similar regarding altitude-maintenance performance. Although the experiment appears redundant, the replication increases external validity and disputes the alternative hypothesis of the results being due to non-realistic scenarios of flying over trees, all with the same height, along a path. The results offer more generalization thus demonstrating how the study is applicable to the world.

Though the study had high internal validity, the role of learning visual cues to maintain altitude may be mentioned as a potential confound. Gray et al. dismiss the possibility as they argue that if learning of visual cues was evident, area would have been noted as a cue as it was presented in the first experiment before being controlled in the third experiment. Likewise, learning angular tree height would have been present in the first experiment due to the control of tree height within each trial. Also, different subjects participated in the second experiment, so they did not have the opportunity to learn from the cues tested. However, as shown in the results, altitude-maintenance still was affected by the visual cue (radius). Although one may be skeptical in results due to individual differences, this circumstance serves as a means to eliminate the "greater" confound of learning; all participants were trained in the stimulation program and pre-tested in eyesight, so other differences may not hold a substantial, if any, effect on the results of performance. Hence, learning would not be considered as problematic.

When visual occlusion cues altitude by means of height, density, and radius, altitude-maintenance performance is also affected. Furthermore, the interaction of cues, height and density or radius and density, produces greater variance in performance as demonstrated by the results of the mentioned experiments. With this research, people can implicate altitude-maintenance performance with the use of visual cues. The study recognizes how density may not be a primary cue to maintaining altitude nor changes in angular size. However, it would be interesting to study larger objects to see if any of these studied variables would hold more, if any, significance. This could also be a challenge, because one would have to find the threshold of density as it varies with angular size. Also the challenge exists, because once the density or angular size exceeds threshold, height and radius no longer serve as a cue. For instance, with density, as the number of trees/km^2, the need to rely on other cues decreases. Additional research could be studied involved visual occlusion and its effect on motion perspective by studying ground occlusion. This study serves purpose for offering insight on the influence of the magnitude of occlusion and its effect on flight performance. Pilots can use this information to know which visual cues to use to assist in their altitude-maintenance, wider and taller objects, to prevent collision while simultaneously avoid detection. Likewise, if this study had not been conducted, people could continue diverting their attention to other cues or just one cue, compared to the product of two cues, which could prevent the decline in collisions or detections. The over topic could also be incorporated by any means of object displacement when facing unwanted obstacles and how to prioritize one's cues.

Reference

Gray, R., Geri, G.A., Akhtar, S.C., & Covas, C.M. (2008, April).The Role of Visual Occlusion in Altitude Maintenance During Simulated Flight. *Journal of Experimental Psychology: Human Perception and Performance*, 34(2), *475-488*. doi:10.1037/0096-1523.34.2.475